Ontario

Apprenticeship
In-school Curriculum Standards

Instrumentation and Control Technician

Level I

447A

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Introduction

This Instrumentation and Control Technician Curriculum Standard has been developed in keeping with the Common Format Guidelines prescribed by the Ministry of Training Colleges and Universities (MTCU) from the trade workplace Performance Objectives. The curriculum standard reflects the content necessary for appropriate progression through each level of the Instrumentation and Control Technician in-school apprenticeship program.

For easy reference, a time allocation has been included for each respective reportable subject, along with a breakdown of theory and application in the delivery of the learning objectives.

The continual introduction of innovative techniques and more complex equipment is resulting in increasing demands for service technicians who are not only skilled in the practical aspects of the trade, but who also have a sound theoretical knowledge of the testing, diagnosing and servicing requirements. The curriculum standard has been developed to provide this theoretical knowledge and to offer some practical applications to complement the on-the-job work experience of the Instrumentation and Control Technician.

The curriculum standard has been designed to give the instructor every opportunity for flexibility and innovation without significant departures from content. Since the scope of the prescribed curriculum standard is quite extensive, the apprentice will be expected to reinforce the acquired knowledge through regular independent out-of-classroom assignments.

The curriculum standard includes specific references to the apprenticeship on-the-job training standards. While terminal performance objectives in the training standards have been linked to the respective in-school learning outcomes and learning content objectives, employers should not assume complete coverage in all aspects of the objectives. The in-school delivery focuses primarily on the knowledge required and fundamental skills that support the respective performance objectives outlined in the workplace training standards. Employers are expected to complete the delivery of these objectives by applying the prescribed in-school knowledge to the practical learning experiences in the work setting.

Regular evaluations of an apprentice's learning achievements must be performed in both theory and practical applications throughout the program.

Program Summary of Reportable Subjects

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practice
S0370	Applied Trade Practices and Procedures	9	9	0
S0371	Electrical Theory and Applied Trade Calculations I	63	37	26
S0372	Electronic Systems I	63	30	33
S0373	Computers and Documentation	30	1	29
S0374	Instrumentation I	75	33	42
	Total	**240**	**110**	**130**

Program Summary by Reportable Subject & Evaluation & Testing

Number: S0370

Title: Applied Trade Practices and Procedures

Duration: Total Hours: 9

Theory: 9 Hours Practical: 0 Hours

Prerequisites: None

Co-requisites: None

Evaluation Structure:

Theory Testing	70%
Practical Exercises	0%
Final Assessment	30%

Reportable Subject

Number:	S0370.1	
Title:	Health and Safety	
Duration:	Total hours:	2
	Theory:	2
	Practical:	0

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6420.02, 6420.03, 6420.04

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to explain relevant safe work practices, policies and procedures according to government safety regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

1.1.1 Explain the significance of workplace legislation including the Occupational Health and Safety Act, WHMIS and Materials Safety Data Sheets (MSDS).

- Occupational Health and Safety Act (OHSA)
- Workplace Hazardous Material Information System (WHMIS)
- Material Safety Data Sheets (MSDS)

1.1.2 Describe the proper use of relevant personal protective equipment.

1.1.3 Describe the effect of electricity on the human body.

1.1.4 Describe zero energy state.

1.1.5 Describe intrinsic safety requirements.

Number: S0370.2

Title: Trade Standards and Codes

Duration: Total hours: 2

Theory: 2
Practical: 0

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6420.02, 6420.05, 6420.06, 6423.10

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to describe Trade Standards and Codes according to government safety regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

1.2.1 Define the Instrumentation and Control Trade Standards and Codes.

1.2.2 Describe the application of Instrumentation and Control Trade Standards and Codes.

1.2.1 Define the Instrumentation and Control Trade Standards and Codes.

- Instrumentation Systems Automation Society (ISA)
- Canadian Standards Association (CSA)
- The Ontario Electrical Safety Code (OESC)
- American National Standards Institute (ANSI)
- International Standards Organization (ISO)

1.2.2 Describe the application of Instrumentation and Control Trade Standards and Codes.

- Instrumentation Systems Automation Society (ISA)
- Canadian Standards Association (CSA)
- The Ontario Electrical Safety Code (OESC)
- American National Standards Institute (ANSI)
- International Standards Organization (ISO)

Number: S0370.3

Title: Tools and Equipment

Duration: Total hours: 3

Theory: 3
Practical: 0

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6422.01, 6422.02

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to describe the construction and application of tools and equipment required for the instrumentation and control trade according to government safety regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

1.3.1 Identify the tools and equipment required for the instrumentation and control trade.

1.3.2 Describe the construction and application of tools and equipment required for the instrumentation and control trade.

1.3.1 Identify the tools and equipment required for the instrumentation and control trade.

- Trade related hand tools
- Measuring devices such as:
  - Digital Multi Meter
  - Calibrators
  - Standards (primary/secondary)

1.3.2 Describe the construction and application of tools and equipment required for the instrumentation and control trade.

- Measuring devices such as:
  - Digital Multi Meter
  - Calibrators
  - Standards (primary/secondary)

Number: S0370.4

Title: Lock out and Tag out Procedures

Duration: Total hours: 2

Theory: 2
Practical: 0

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6420.06

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to describe the lock – out and tag – out procedures for equipment according to government safety regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

1.4.1 Describe the lock-out and tag out procedures for equipment.

- Determine which conditions would cause mechanical and electrical equipment to be tagged and locked out.
- Describe how to lock out mechanical and electrical equipment according to all applicable codes and customer/company standards.
- Describe tagging procedures of defective mechanical and electrical equipment according to all applicable codes and customer/company standards.
- Describe how to remove locked out mechanical and electrical equipment according to all applicable codes and customer/company standards.
- Describe safety procedures involved in working on process equipment such as:
  - Acquisition of work permits
  - Required notification processes

S0370: Recommended Minimum Equipment:

- Safety glasses
- Steel toe boots – CSA certified
- OHSA – booklet
- Variety of PPE – (Scott pack, harness, etc)

Number:	S0371
Title:	**Electrical Theory and Applied Trade Calculations I**
Duration:	Total Hours: 63
	Theory: 37 Hours Practical: 26 Hours
Prerequisites:	None
Co-requisites:	None

Evaluation Structure:

Theory Testing	40%
Practical Exercises	30%
Final Assessment	30%

Number: S0371.1

Title: Electrical Fundamentals

Duration: Total hours: 10

Theory: 8
Practical: 2

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6423.0, 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to describe the electrical fundamentals and apply mathematical tools according to prescribed industry standards.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

2.1.1 Define the terms and fundamentals of electricity.

2.1.2 Describe the features and applications of electrical and mechanical energy.

2.1.3 Describe the effects of electricity on the human body.

2.1.4 Explain the principles of common sources of Electro-Motive Force (EMF).

2.1.1 Define the terms and fundamentals of electricity.

- Voltage
- Amperage
- Resistance (colour codes) (impedance)
- Ohms Law
- Kirchoff's Law
- Direct Current
- Alternating Current
- Electro-Motive Force (EMF)
- Potential Difference (PD)
- Electrical Sources

2.1.2 Describe the features and applications of electrical and mechanical energy.

- Wattage
- Amperage
- Power
  - power and heat loss

2.1.3 Describe the effects of electricity on the human body.

- Visible effects
- Invisible effects

2.1.4 Explain the principles of common sources of Electro-Motive Force (EMF).

- Magnetism
- Motor Principles
- Generator Principles

Number: S0371.2

Title: Electrical Test Equipment

Duration: Total hours: 3

Theory: 3
Practical: 0

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6422.02, 6422.03

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to explain the principles of operation and application of electrical test equipment used in the instrumentation trade according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.2.1 Identify the electrical test equipment types and applications used in the Instrumentation and Controls technician Industry.

2.2.2 Explain the principle of operation and application of electrical test equipment such as:

- Digital Multi Meter
- Clamp on ammeter
- Insulation Tester
- Milivolt Calibrators
- Current Calibrators

Number: S0371.3

Title: Electrical Control Devices

Duration: Total hours: 25

Theory: 13
Practical: 12

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to explain the application, assemble and test electrical control devices used in typical industry applications.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

2.3.1 Describe the fundamental principles of electrical control devices such as:

- Wheatstone bridge
- Transformers
- Solenoids
- Relays

2.3.2 Explain the applications of a "Wheatstone bridge".

2.3.3 Explain the applications of "Transformers".

2.3.4 Explain the applications of "Solenoids".

2.3.5 Explain the applications of "Relays".

2.3.6 Assemble and test Wheatstone bridges, transformers, solenoids and relay circuits.

Number: S0371.4

Title: Electrical Circuits

Duration: Total hours: 25

Theory: 13
Practical: 12

Prerequisites: None

Co-requisites: None

Duration: Total Hours: 25

Theory: 13
Practical: 12

Cross-Reference to Training Standard Performance Objectives: 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to assemble, analyze and troubleshoot electrical circuits, applying mathematical tools and using electronic test equipment according to typical industry applications.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

2.4.1 Analyze direct current (DC) circuits by applying Ohm's law and Kirchoff's law.

2.4.2 Calculate voltage, current, resistance and power of DC electrical circuits.

2.4.3 Assemble series, parallel and combined DC circuits.

2.4.4 Measure the voltage, current and resistance of series, parallel and combined circuits.

2.4.5 Troubleshoot series, parallel and combined DC circuits.

2.4.1 Analyze direct current (DC) circuits by applying Ohm's law and Kirchoff's law.

- Series Circuits
- Parallel Circuits
- Combination Direct Current (DC) Circuits.

2.4.2 Calculate voltage, current, resistance and power of DC electrical Circuits.

- Series circuit calculations for total resistance.
- Series circuit calculations for total current draw.
- Series circuit calculations for total voltage.
- Parallel circuit calculations for total current draw.
- Parallel circuit calculations for total resistance.
- Parallel circuit calculations for total voltage.
- Combined circuit calculations for total resistance.
- Combined circuit calculations for total current draw.
- Combined circuit calculations for total voltage draw.

2.4.3 Assemble series, parallel and combined DC circuits.

2.4.4 Measure the voltage, current and resistance of series, parallel and combined circuits.

2.4.5 Troubleshoot series, parallel and combined DC circuits.

S0371: Recommended Minimum Equipment:

- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Variable DC power supply – 0 to 40 Vdc
- Assorted resistors
- Assorted electrical loads (Lights, relays, solenoid valves)
- Assorted transformers (Step up, step down, Isolation)
- Prototype board – Circuit assembly
- Clamp-on ammeter
- Insulation tester
- Instrumentation calibrators (current, voltage)

Number:	S0372	
Title:	**Electronic Systems I**	
Duration:	Total Hours: 63	
	Theory: 30 Hours	Practical: 33 Hours
Prerequisites:	None	
Co-requisites:	None	

Evaluation Structure:

Theory Testing	35%
Practical Exercises	35%
Final Assessment	30%

Number: S0372.1

Title: Electronic Fundamentals

Duration: Total hours: 12

Theory: 6
Practical: 6

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOME

On successful completion, the apprentice is able to assemble, measure and troubleshoot semi-conductor components and circuits used in the industrial process controls industry.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.1.1 Identify basic semi-conductors and symbols used in instrumentation and control systems.

3.1.2 Describe the application of basic semi-conductor components.

3.1.3 Explain the operation of basic semi-conductor components.

3.1.4 Assemble; measure and troubleshoot a variety of basic semi-conductor circuits.

3.1.1 Identify basic semi-conductors and symbols used in Instrumentation and control systems.
- Diodes
- Transistors
- LED'S
- Optocouplers

3.1.2 Describe the application of basic semi-conductor components such as:
- Diodes
- Transistors
- LED'S
- Optocouplers

3.1.3 Explain the operation of basic semi-conductor components such as:
- Diodes
- Transistors
- LED'S
- Optocouplers

3.1.4 Assemble; measure and troubleshoot a variety of basic semi-conductor circuits

Number: S0372.2

Title: Electronic System Test Equipment

Duration: Total hours: 10

Theory: 3
Practical: 7

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6422.02, 6422.03, 6423.06, 6433.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to describe the recommended procedures and use electronic test equipment according to government regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.2.1 Identify the function of electronic test equipment.

3.2.2 Describe the recommended procedures to use electronic test equipment.

3.2.3 Use electronic test equipment to verify the operation of electronic circuits.

3.2.1 Identify the function of electronic test equipment such as:

- Oscilloscope
- Frequency counter
- Function generator
- Meter loading

3.2.2. Describe the recommended procedures to use electronic test equipment such as:

- Oscilloscope
- Frequency counter
- Function generator
- Meter loading

3.2.3. Use electronic test equipment to verify the operation of electronic circuits.

Number: S0372.3

Title: Electronic Circuits and Schematics

Duration: Total hours: 41

Theory: 21
Practical: 20

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6423.01, 6525.02, 6427.03, 6428.08, 6430.05, 6433.03

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to assemble, measure and troubleshoot basic logic gate circuits and schematics according to applications in the industrial instrumentation and controls industry.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

3.3.1 Identify schematic symbols for North American and European basic logic gates.

3.3.2 Describe the operation of basic logic gates and use basic logic gates to create digital logic circuits.
3.3.3 Explain the operating principles of basic logic gates.
3.3.4 Identify and define Boolean equations for simple logic gates.
3.3.5 Describe the electrical requirements for electronic circuits such as:

- Circuit loading
- Voltage/Current levels

3.3.6 Assemble; measure and troubleshoot a variety of basic logic circuits.

S0372: Recommended Minimum Equipment:

- Assorted transistors
- Assorted diodes
- Assorted LEDs
- Optocouplers
- Oscilloscopes
- Frequency counters
- Function generators
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Variable DC power supply – 0 to 40 Vdc
- Assorted resistors
- Assorted electrical loads (Lights, relays, solenoid valves)
- Assorted transformers (Step up, step down, isolation)
- Prototype board – Circuit assembly
- Standard screwdrivers, Phillips screwdrivers, prototype board, lead wire, scope probe 10X, side cutters, wire stripper, soldering iron

Number: S0373

Title: **Computers and Documentation**

Duration: Total Hours: 30

Theory: 1 Hours Practical: 29 Hours

Prerequisites: None

Co-requisites: None

Evaluation Structure:

Theory Testing	5%
Practical Exercises	65%
Final Assessment	30%

Number: S0373.1

Title: Computer Fundamentals

Duration: Total hours: 2

Theory: .5
Practical: 1.5

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6421.02, 6421.03, 6421.04

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to perform operations on microcomputers in accordance with manufacturers and installed software recommendations.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

4.1.1 Identify the purpose and function of basic computer components.

4.1.2 Operate a microcomputer (by utilizing fundamental commands necessary for the proper operation of modern computer software)

4.1.1 Identify the purpose and function of basic computer components.

- Hard drive
- Peripheral devices
- Input/output ports
- Power Supply
- Mother Board

4.1.2 Operate a microcomputer by utilizing fundamental commands necessary for the proper operation of modern computer software such as:

- Basic Input Operating Systems (BIOS)
- Operating Systems

Number: S0373.2

Title: Computer Software

Duration: Total hours: 2

Theory: .5
Practical: 1.5

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6421.02, 6421.03, 6421.04, 6423.01, 6430.05

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to describe computer software applications used to create Process and Instrument (P&I), wiring and loop diagrams; and to produce computerized presentations and technical documentations by incorporating information from multiple sources.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

4.2.1 Identify and describe the features of computer software applications.

4.2.2 Navigate software menus.

4.2.1 Identify and describe the features of computer software applications.

- Word Processing
- Presentation Software
- Spreadsheets
- Computer-assisted design (CAD)

4.2.2 Navigate software menus.

- Word processing
- Spreadsheets
- Computer-assisted design (CAD)
- Presentation Software

Number: S0373.3

Title: Computer Generated Documents

Duration: Total hours: 26

Theory: 0
Practical: 26

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6421.02, 6421.03, 6421.04, 6423.01, 6430.05

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to use computer software to create Process and Instrument (P&I), wiring and loop diagrams; and to produce computerized presentations and technical documentations by incorporating information from multiple sources.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.3.1 Perform computer functions.

- Import and export functions for graphs, tables and drawings between applications.
- Create a document containing most of the elements common to technical reports such as tables and graphics.
- Draw P & I, electrical and loop diagrams by using CAD software.
- Use ISA symbols.
- Save files to a storage device, and make backup copies.
- Plot drawings by using various printers or plotters.
- Use computers to document laboratory procedures and explain the function/operation of work.
- Use spreadsheet software for graphing of calibration or other data.

S0373: Recommended Minimum Equipment:

- Personal computers – (minimum capability to run Windows 2000)
- Keyboard, mouse
- 80 GB hard drive
- 512MB RAM
- CD reader
- 17" monitor
- Software – (Word processor, Spreadsheet, CAD, presentation software)
- Printer

Number:	S0374
Title:	**Instrumentation I**
Duration:	Total Hours: 75
	Theory: 33 Hours Practical: 42 Hours
Prerequisites:	None
Co-requisites:	None

Evaluation Structure:

Theory Testing	30%
Practical Exercises	40%
Final Assessment	30%

Number: S0374.1

Title: Introduction to Instrumentation

Duration: Total hours: 45

Theory: 23
Practical: 22

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to identify and explain the principles of operation and calibrate temperature, pressure, level and flow measurement instruments by applying theory and performing laboratory experiments:

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

5.1.1 Explain the terminology and symbology used in instrumentation.

5.1.2 Describe the operation and application of pressure, temperature, level and flow measuring devices.

5.1.3 Describe the features of instrumentation and control devices.

5.1.4 Calibrate pressure, temperature, level and flow transmitters.

5.1.1 Explain the terminology and symbology used in instrumentation.

5.1.2 Describe the operation and application of pressure, temperature, level and flow measuring devices.

- Define temperature as a measure of heat energy.
- Explain common temperature scales and their relationship.
- Explain the physics of heat transfer.
- Define pressure and explain its significance in process control.
- Explain absolute, gauge, head, and hydrostatic and differential pressure.
- Identify and define the types of pressure elements.
- Explain Pascal's Law and its application.
- Explain flow rates.
  - volumetric
  - mass flow
- Explain fluid physical properties and factors that affect flow measurement.

5.1.3 Describe the features of instrumentation and control devices.

- Describe instruments used for temperature measurement.
- Identify common pressure scales and units used in pressure measurement.
- Describe instruments used for pressure measurement.
- Explain important considerations in pressure measurement using manometers.
- Explain devices used in the calibration of pressure sensors.
- Explain the importance of level measurement.

- Explain point level measurement versus continuous level measurement.
- Describe instruments used for level measurement.
- Describe instruments used for flow measurement.

5.1.4 Calibrate pressure, temperature, level and flow transmitters.

Number: S0374.2

Title: Instrumentation Installation Techniques

Duration: Total hours: 30

Theory: 10
Practical: 20

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6423.04, 6423.05, 6424.01, 6433.02

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to install instruments and control systems according to government regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

5.2.1 Describe installation techniques for tubing used in instrumentation and control systems.

5.2.2 Describe installation techniques for conduit used in instrumentation and control systems.

5.2.3 Describe installation techniques for wiring and circuit boards used in instrumentation and control systems.

5.2.4 Install tubing used in instrumentation and control systems.

5.2.5 Install conduit used in instrumentation and control systems.

5.2.6 Install wires and circuit boards used in instrumentation and control systems.

5.2.1 Describe installation techniques for tubing used in instrumentation and control systems.

- Tube layout and measuring
- Tube cutting
- Calculate tube bending lengths for various configurations that use different angles.
- Joining tubing with compression fittings, flare fittings and solder.

5.2.2 Describe installation techniques for conduit used in instrumentation and control systems.

- Threading of steel conduit using hand threading tools.
- Installing threaded pipe and fittings for a safe, leak-tight installation.
- Fabrication of simple metal brackets.

5.2.3 Describe installation techniques for wiring and circuit boards used in instrumentation and control systems.

- Soldering and de-soldering electronic components on a printed circuit board.
- Identify static and anti-static devices when working with electronic components.
- Wire-stripping and terminating practices.
- Installation of wire and connection of temperature, pressure, level and flow measurement instruments.

5.2.4 Install tubing used in instrumentation and control systems.

- Sketch and measure tube layouts.
- Cut and bend tubing.
- Join tubing with compression fittings, flare fittings and solder.
- Test tube joints for leaks.

5.2.5 Install conduit used in instrumentation and control systems.

- Thread steel conduit using hand threading tools.
- Install threaded pipe and fittings for a safe, leak-tight installation.
- Fabricate simple metal brackets.

5.2.6 Install wires and circuit boards used in instrumentation and control systems.

- Solder and de-solder electronic components on a printed circuit board
  - use static and anti-static devices when working with electronic components.
- Strip wires and terminate wires.

S0374: Recommended Minimum Equipment:

- Copper instrument tubing ¼"
- Tubing bender, cutter, reamer
- Assorted tube fittings, compression fittings, hand valves
- Standard screwdrivers, DMM, crescent wrench, Allen keys, Phillips screwdrivers, pressure calibrator, DWT, current calibrator, safety glasses, lead wire, side cutters, wire stripper, soldering iron
- Pressure standards – Inclined & U tube manometers, pressure calibrator ± .25%, DWT (Dead Weight Tester) and test gauges
- PRV – Pressure regulating valve
-
- Compressed air supply (2.5 cfm @ 90 psi min.)
- Variety of pressure indicators – (0 to 100psig, 30" Hg vac to 30 psig, inches or cm of w.c.), Bourdon, Magnehelics
- Variety of pressure switches – (0 to 100 psig)
- Variety of pressure transmitters (25 to 250 in. w.c., 0 to 30 psig) 4 – 20 mA
- Variety of differential pressure transmitters
- Variety of level switches
- Variety of level transmitters
- Variety of temperature indicators (glass thermometers, bimetal, IR non contact)
- Variety of temperature elements (thermocouple, RTD, thermistor)
- Variety of temperature switches
- Variety of temperature transmitters
- Flow indicators – rotameters
- Variety of flow switches

- Variety of flow transmitters (Bernoulli types, magmeter, positive displacement, etc.)
- DC supply (minimum 24Vdc @ 100mA)
- Steel pipe and tap & die set (¼" to 1"),
- Assorted pipe fittings

Summary of Equipment Required for Level I

S0370: Recommended Minimum Equipment:

- Safety glasses
- Steel toe boots – CSA certified
- OHSA – booklet
- Variety of PPE – (Scott pack, harness, etc)

S0371: Recommended Minimum Equipment:

- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Variable DC power supply – 0 to 40 Vdc
- Assorted resistors
- Assorted electrical loads (Lights, relays, solenoid valves)
- Assorted transformers (Step up, step down, Isolation)
- Prototype board – Circuit assembly
- Clamp-on ammeter
- Insulation tester
- Instrumentation calibrators (current, voltage)

S0372: Recommended Minimum Equipment:

- Assorted transistors
- Assorted diodes
- Assorted LEDs
- Optocouplers
- Oscilloscopes
- Frequency counters
- Function generators
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Variable DC power supply – 0 to 40 Vdc
- Assorted resistors
- Assorted electrical loads (Lights, relays, solenoid valves)
- Assorted transformers (Step up, step down, isolation)
- Prototype board – Circuit assembly
- Standard screwdrivers, Phillips screwdrivers, prototype board, lead wire, scope probe 10X, side cutters, wire stripper, soldering iron

S0373: Recommended Minimum Equipment:

- Personal computers – (minimum capability to run Windows 2000)
- Keyboard, mouse
- 80 GB hard drive
- 512MB RAM
- CD reader
- 17" monitor
- Software – (Word processor, Spreadsheet, CAD, presentation software),
- Printer

S0374: Recommended Minimum Equipment:

- Copper instrument tubing ¼"
- Tubing bender, cutter, reamer
- Assorted tube fittings, compression fittings, hand valves
- Standard screwdrivers, DMM, Crescent wrench, Allen keys, Phillips screwdrivers, pressure calibrator, DWT, current calibrator, safety glasses, lead wire, side cutters, wire stripper, soldering iron
- Pressure standards – Inclined & U tube manometers, pressure calibrator ± .25%, DWT (Dead Weight Tester) and Test gauges
- PRV – Pressure regulating valve
- Compressed air supply (2.5 cfm @ 90 psi min.)
- Variety of pressure indicators – (0 to 100psig, 30" Hg vac to 30 psig, inches or cm of w.c.), Bourdon, Magnehelics
- Variety of pressure switches – (0 to 100 psig)
- Variety of pressure transmitters (25 to 250 in. w.c., 0 to 30 psig) 4 – 20 mA
- Variety of differential pressure transmitters
- Variety of level switches
- Variety of level transmitters
- Variety of temperature indicators (glass thermometers, bimetal, IR non contact)
- Variety of temperature elements (thermocouple, RTD, thermistor)
- Variety of temperature switches
- Variety of temperature transmitters
- Flow indicators – rotameters
- Variety of flow switches
- Variety of flow transmitters (Bernoulli types, magmeter, positive displacement, etc.)
- DC supply (minimum 24Vdc @ 100mA)
- Steel pipe and tap & die set (¼" to 1"),
- Assorted pipe fittings